CLAIMS

1. A thermoformable panel, characterized in that it is composed of interlaced thermoplastic fibers forming a non-woven fabric, pressed under heating to cause al least partial melting of fibers, i.e. at least a partial loss of their fibrous phase and change into a viscous or viscoelastic phase, the relative distributions of the fraction of fibers that retain the fibrous phase and the fraction of plastic material that took the viscous or viscoelastic state depending on the depth thereof in the sheet thickness.

2. A panel as claimed in claim 1, characterized in that as a function of the depth in the panel thickness the fibers shows a continuous change of phase from a first phase provided at the two opposite faces of the panel and in which phase all or almost all the fibers has been submitted to a melting, i.e. ti a phase transition in which all or almost all the fibers has completely or almost completely lost their fibrous phase into a second phase at an intermediate, preferably central region of the panel where the fibers has completely or almost completely maintained their fibrous phase, i.e. has maintained their shape and individuality.

3. A panel as claimed in claims 1 or 2, characterized in that the plastic component that retained its fibrous phase is preferably in the central portion of the panel thickness.

4. A panel as claimed in one or more of the preceding claims, characterized in that the

distribution of fibrous components and viscous or viscoelastic components of the thermoplastic material is symmetric with respect to the median plane of the panel.

5. A panel as claimed in one or more of the preceding claims, characterized in that the distribution of fibrous components and viscous or viscoelastic components of the thermoplastic material is asymmetric with respect to the median plane of the panel.

6. A panel as claimed in one or more of the preceding claims, characterized in that the distribution of fibrous components and of viscous or viscoelastic components of the thermoplastic material within the panel thickness is non linear with respect to the penetration depth along the panel thickness toward the median plane thereof, the viscous or viscoelastic component of the thermoplastic material being larger or prevalent in a thin surface layer or in the two surface layers, whereas the fibrous component is prevalent in the portion of the panel thickness immediately underlying said two opposite surface layers.

7. A panel as claimed in claim 6, characterized in that the variation in the relative distribution of the fibrous and viscous or viscoelastic components of the thermoplastic material toward increase of the fibrous component as compared with the viscous or viscoelastic component is fast, i.e. is controlled by a ripid gradient function, i.e a gradient function being

more ripid than a linear function with a parameter 1, as the depth in the panel thickness increases toward the median plane, at least from one of the two surface layers.

8. A panel as claimed in claim 6, characterized in that the variation in the relative distribution of the fibrous and viscous or viscoelastic components of the thermoplastic material toward increase of the fibrous component as compared with the viscous or viscoelastic component is slow and gradual, i.e. is controlled by a non ripid gradient function, i.e a gradient function being less ripid than a linear function with a parameter 1, as the depth in the panel thickness increases toward the median plane, at least from one of the two surface layers.

9. A panel as claimed in one or more of the preceding claims, characterized in that the thermoplastic material is a blend of at least two kinds of thermoplastic fibers having different melting and/or softening temperatures the said blend of thermoplastic fibers having the following continuous phase variation as a function of the depths of penetration:

a first phase provided at the two opposite faces of the panel and in which phase all or almost all the fibers of the at least two kind has been submitted to a melting, i.e. a phase transition in which all or almost all the fibers of the at least two kind has completely or almost completely lost their fibrous phase into a second phase at an intermediate, preferably central region of the panel where both the fibers of the at

least two kind the fibers of only one kind has completely or almost completely maintained their fibrous phase, i.e. has maintained their shape and individuality, passing through intermediate phases at intermediate depth of penetration in the thickness of the panel where the fibers of one kind has a more rapid change as a function of penetration in the thickness depth than the fibers of the at least second kind, thereby providing at intermediate penetration depth between the surface of the panel and the central portion a first kind of fibers having a prevalent part of them in a fibrous phase and at least a second part of fibers having a prevalent part or almost all of them in a viscous or viscoelastic phase and/or with further increase in the depth of penetration toward the central portion of the panel a first part of fibers having a prevalent part or almost all of them a fibrous phase while the at least second kind of fibers having formed physico-chemical bondings between the first kind of fibres.

10. A panel as claimed in one or more of the preceding claims, characterized in that the thermoplastic material comprises one polyolefin or a mixture of polyolefins.

11. A panel as claimed in claim 9, characterized in that the thermoplastic material is made of polymer or copolymer fibers from the polyethylene group or mixtures thereof.

12. A panel as claimed in claim 9, characterized in that the thermoplastic material is made of polymer

or copolymer fibers from the group of polyethylene ethers or mixtures thereof.

13. A panel as claimed in claim 12, characterized in that the thermoplastic material is composed of polyethylene glycol ether phthalate terpolymer.

14. A panel as claimed in one or more of the preceding claims, characterized in that the thermoplastic fibers are randomly oriented.

15. A panel as claimed in one or more of the preceding claims, characterized in that it is made out of thermoplastic fibers by heating a mat having one or more nonwoven fabric layers of said thermoplastic fibers, which layers are joined together by interlacement and/or heat bonding (self bonding), said mat of nonwoven fabric layers being submitted to violent or hard heating at a predetermined melting and/or softening temperature of the fibers which is considerably higher than the melting temperature of the plastic fibers of the panel having the highest melting or softening temperature and for a predetermined time, and being further submitted to a compression to such an extent as to cause a thickness reduction from the uncompressed condition to the compressed condition by about 30% to about 90% of the uncompressed thickness of the mat made of the nonwoven fabric layers.

16. A panel as claimed in one or more of the preceding claims 1 to 15, characterized in that heating is provided by radiation.

17. A panel as claimed in one or more of the preceding claims 1 to 15, characterized in that heating

is provided by infrared radiation.

18. A panel as claimed in one or more of the preceding claims, characterized in that heating is provided in one step or in subsequent steps.

19. A panel by means of a hot air flow and/or radiation and/or direct contact with hot surfaces.

20. A panel as claimed in one or more of the preceding claims, characterized in that at least one of the hot heating surfaces consist of at least one surface of a compression mold used for thermoforming by mold and countermold systems and/or hydraulic and/or pneumatic pressure and/or vacuum.

21. A panel as claimed in one or more of the preceding claims, characterized in that a preheating and preventive compression phase is provided in which compression of the mat made of nonwoven fabric layers and heating are performed by calendering with heated rollers at a temperature lower than the melting or softening temperature of the thermoplastic fibers.

22. A panel as claimed in one or more of the preceding claims, characterized in that the heating temperature at the mat surface is of 100°C to 300°C, and particularly of 160°C to 200°C.

23. A panel as claimed in one or more of the preceding claims, characterized in that the mat made of nonwoven fabric layers has a weight of 100 to 4000 g/m^2, preferably of 1000 to 3000 g/m^2.

24. A panel as claimed in one or more of the preceding claims, characterized in that the sheet and the mat made of nonwoven fabric layers have, on one or

both faces thereof and/or in an intermediate position of one or more layers, a net, a thermoplastic fiber fabric attached by physico-chemical bonding, particularly by heat bonding.

25. A panel as claimed in one or more of the preceding claims, characterized in that an adhesive layer is provided on one or both faces.

26. A panel as claimed in claim 23, characterized in that the adhesive material consists of a polyolefin-based polymer or copolymer layer, which is surface-treated to increase polarity.

27 A panel as claimed in one or more of the preceding claims, characterized in that it is an intermediate or semi-finished product for the fabrication of thermoplastic formed panels by further molding the panel in a mold under heat and compression.

28. A panel according to one or more of the preceding claims characterized in that the panel has a non plane shape being formed in three dimensions in the compression stage by a mold and countermold system.

29. A panel as claimed in one or more of the preceding claims, characterized in that the portions of the panel thickness in which all or almost all the fibers or a prevalent number of fibers has a viscous or viscoelastic phase are thin surface layers.

30. A panel as claimed in one or more of the preceding claims, characterized in that a covering layer made of fabric, nonwoven fabric, mesh or interlaced synthetic or natural fibers, a thin plastic sheet, a leather or imitation leather sheet and/or

combinations thereof are attached on at least one of the panel surfaces, on different portions of said panel.

31. A panel as claimed in claim 30, characterized in that the covering layer is made of a single layer.

32. A panel as claimed in one or more of the preceding claims, characterized in that the covering layer is made of several layers and comprises at least one additional adhesive layer interposed between the thermoplastic layer and the covering layer.

33. A panel as claimed in claim 32 or 33, characterized in that the covering layer further includes an outer finishing layer, composed of a thin thermoplastic sheet, like a scratch resistant sheet or a UV-filtering sheet.

34. A formed panel as claimed in one or more of the preceding claims, characterized in that the panel has coating layer as claimed in one or more of the preceding claims 33 to 24 also on both faces.

35 A panel according to one or more of the preceding claims characterized in that the panel has smooth surfaces.

36. A method for fabricating a thermoformable panel as claimed in one or more of the preceding claims, including the steps of:

a) providing a mat of thermoplastic fibers;

b) heating the mat to a temperature higher than the melting or softening temperature of the plastic material of the fibers having the highest melting or softening temperature;

c) compressing the mat to such an extent to obtain a 30% to 90% reduction of the starting thickness of the mat.

37. A method as claimed in claim 36, characterized in that the fiber mat is made of randomly oriented thermoplastic fibers.

38. A method as claimed in claim 36 or 37, characterized in that the fiber mat is made of a plurality of layers of interlaced thermoplastic fibers.

39. A method as claimed in one or more of claims 36 to 38, characterized in that the fiber mat is made of interconnected fabric or nonwoven fabric layers of thermoplastic fibers not being needled.

40. A method as claimed in one or more of the preceding claims 36 to 39, characterized in that the fibrous layers are interconnected by mechanical interlacement and/or by physico-chemical bonding, particularly by heat bonding.

41. A method as claimed in one or more of the preceding claims 36 to 40, characterized in that the uncompressed fiber mat has a weight of 100 to 4000 g/m^2, preferably of 1000 to 3000 g/m^2.

42. A method as claimed in one or more of the preceding claims 36 to 41, characterized in that heating is provided by infrared radiation on the outer faces of the fiber mat immediately before compression.

43. A method as claimed in one or more of the preceding claims 36 to 42, characterized in that heating is provided by contact with hot heater elements against the fiber mat immediately before compression

and/or during it and/or solely during compression.

44. A method as claimed in one or more of the preceding claims 36 to 43, characterized in that the mat is heated to a temperature of 150°C to 300°C, preferably of 200°C to 250°C for a time varying between 10 and 100 seconds.

45. A method as claimed in one or more of the preceding claims 36 to 44, characterized in that a further step of compressing the mat by calendering is provided before heating.

46. A method as claimed in claim 45, characterized in that a preheating at a temperature lower than the melting temperature of the fibers is carried out during calendering, the calender rollers being heated rollers.

47. A method as claimed in one or more of the preceding claims 36 to 46, characterized in that heating provides a transition in the state of a portion of the thermoplastic fibers from the fibrous state to a at least partially or completely viscous or viscoelastic state for a certain depth of penetration in the thickness of the of the panel starting from at least one surface of the panel by heating the mat with infrared radiation directed on said surface or surfaces, whereby the plastic material at these depth of penetration in the thickness of the panel has a larger component of plastic material in a viscous or viscoelastic phase as compared with the component plastic material in the fibrous phase, the viscous or viscoelastic component gradually and continuously

decreasing toward the median portion of the panel until the distribution of viscous or viscoelastic plastic material and fibrous plastic material is inverted in said median portion, wherein the component of plastic material in the fibrous phase prevails over the component of plastic material in the viscous or viscoelastic phase.

48 A method according to claim 47, characterized in that heating provides a transition in the state of a portion of the thermoplastic fibers from the fibrous state to a at least partially or completely viscous or viscoelastic state of a portion of all or almost all the thermoplastic fibers for a certain depth of penetration in the thickness of the of the panel starting from at least one surface of the panel by heating the mat with infrared radiation directed on said surface or surfaces, whereby the plastic material at these depth of penetration in the thickness of the panel has almost only a component of plastic material in a viscous or viscoelastic phase as compared with the component plastic material in the fibrous phase, the viscous or viscoelastic component gradually and continuously decreasing toward the median portion of the panel until the distribution of viscous or viscoelastic plastic material and fibrous plastic material is inverted in said median portion, wherein the component of plastic material in the fibrous phase prevails over the component of plastic material in the viscous or viscoelastic phase or almost only the component of the plastic material in the fibrous phase

is present.

49. A method as claimed in one or more of the preceding claims 36 to 48, characterized in that it includes the step of attaching a fabric layer or a thermoplastic net layer, on one or both faces of the fiber mat, when the latter is uncompressed or compressed or during the compression step.

50. A method as claimed in one or more of the preceding claims 36 to 49, characterized in that it includes the step of attaching an adhesive layer on one or both faces of the sheet.

51. A method as claimed in claim 50, characterized in that the fabric or net layer and/or the adhesive material are attached during the compression step thanks to the physico-chemical bonding generated as the mat and/or the fabric or the net and/or the adhesive are heated.

52. A method as claimed in claim 51, characterized in that the adhesive is provided as a thin sheet and is attached to the fiber mat during the compression step by hot calendering, by feeding it to the calender rollers over the face/s of the fiber mat.

53. A method as claimed in claim 51, characterized in that the fabric and/or the net are attached to the fiber mat during the compression step by hot calendering, by feeding them to the calender rollers over the face/s of the fiber mat.

54. A method as claimed in claims 51 and 53, characterized in that the thin adhesive layer and the fabric and/or the net are attached together, one over

the other, and onto the face/s of the mat upon during the calendering step.

55. A method as claimed in one or more of the preceding claims 36 to 54, characterized in that the adhesive is applied in powder form, by spreading it over at least one face of the mat in the uncompressed or compressed condition thereof before heating, and by heating said adhesive powder.

56. A method as claimed in one or more of the preceding claims 36 to 55, characterized in that it is adapted to produce a thermoformable panel to be used as an intermediate or semi-finished product for the fabrication of formed panels.

57. A method according to claim 56, characterized in that the intermediate or semi-finished panel is submitted to thermoforming for producing a shaped panel in the three dimensions.

58. A method according to claim 57, characterized in that the panel is heated before forming and or during forming to a softening temperature of the plastic material which is lower that the melting temperature of the thermoplastic fibers and submitted during heating and or after to three dimensional shaping by mechanical compression in a mold and countermold system and/or by compression against a formed surface by using hydraulic and/or pneumatic pressure and/or vacuum against a formed surface and/or by hydraulic and/or pneumatic compression and vacuum.

59 .A method according to one or more of the preceding claims 36 to 55, characterized in that the

mat of fibers is submitted to compression for simultaneous thickness reduction and three dimensional shaping obtaining a three dimensional shaped panel by mechanical compression in a mold and countermold system and/or by compression against a formed surface by using hydraulic and/or pneumatic pressure and/or vacuum against a formed surface and/or by hydraulic and/or pneumatic compression and vacuum.

60. A method as claimed in one or more of the preceding claims 36 to 59, characterized in that before applying a compression for thickness reduction and three dimensional shaping on the heated mat it includes the further steps of:

feeding one or more covering layers for at least one of the sheet faces, one over the other and over the mat or the flat panel to be compressed and/or shaped;

simultaneously attaching the covering layer/s to the sheet during the compression and/or shaping process.

61. A method as claimed in claim 60, characterized in that it includes the additional step of attaching an adhesive layer on the face/s of the panel and/or of the mat of fibers which adhesive layer or layers are designed to be coupled to one or more covering layers.

62. A method as claimed in claim 61, characterized in that the adhesive consists of a thin thermoplastic layer which is fed and coupled to the panel or mat of fibers on at least one of the two faces thereof before forming and coupling the covering

layer/s or while coupling the covering layer/s, the thin layer being fed with the sheet and the covering layers to the forming station.

63. A method as claimed in one or more of the preceding claims 36 to 62, characterized in that, before or during the process for compressing and or forming the panel or the mat of fibers and/or the covering layer/s and/or the adhesive layer/s, the sheet and/or the covering layer/s and/or the adhesive layer are heated together with the panel or mat of fibres or separately.

64. A method as claimed in claim 63, characterized in that it includes the step of heating together the mat of fibers and the covering layer/s and/or the adhesive layer to a temperature of 100°C to 300°C, particularly of 160°C to 200°C and for a time of 10 to 100 seconds.

65. A method according to one or more of the preceding claims characterized in that it includes the step of coupling the covering layer/s and/or the adhesive layer to the mat of fibers during calendering.

66. A panel as claimed in one or more of the preceding claims 1 to 35, characterized in that it has portions with different thicknesses.

67. A panel as claimed in claim 66, characterized in that, in the portions having different thicknesses, a different function is provided for the variations in the distribution of the component having fibrous phase and of the component havng an elastic or viscoelastic phase of the plastic material, depending on the

penetration depth in said thickness of the panel.

68. A method as claimed in one or more of claims 36 to 66, characterized in that the mat of fibers is heated at different temperatures in different portions of the surfaces of the said mat and/or submitted to different reduction of thickness in different portions of the surface of the mat by compressing the mat in a differential manner in said different portions.

69. A method as claimed in one or more of claims 36 to 66, characterized in that the panel is heated at different temperatures in different portions of the surfaces of the said panel and/or submitted to different reduction of thickness in different portions of the surface of the said panel by compressing the panel in a differential manner in said different portions during shaping.

70. A panel as claimed in one or more of the preceding claims 1 to 35 and 67, characterized in that it is used as an interior covering panel for vehicles, particularly automotive vehicles and especially a so-called interior trim for automotive vehicles.

71. A formed panel as claimed in one or more of the preceding claims 1 to 35 and 67, characterized in that it is used as an interior or exterior covering panel for building structures and/or a panel for formworks containing concrete or the like.

72. A formed panel as claimed in one or more of the preceding claims 1 to 35 and 67, characterized in that it is used as an interior or exterior covering panel or a structural element for ships and/or railway

vehicles, especially of the high speed type and/or for aerospace vehicles.

73. A method as claimed in one or more of the preceding claims 36 to 66 and 68 or 69, characterized in that it is a method for fabricating interior covering panels for vehicles, particularly automotive vehicles and especially a so-called interior trim for automotive vehicles.

74. A method as claimed in one or more of the preceding claims 36 to 66 and 68 or 69, characterized in that it is a method for fabricating interior or exterior covering panels, for building structures and/or panels for formworks containing concrete or the like.

75. A method as claimed in one or more of the preceding claims 36 to 66 and 68 or 69, characterized in that it is a method for fabricating interior or exterior covering panels or structural elements for ships and/or railway vehicles, especially of the high speed type and/or for aerospace vehicles.

76. A method as claimed in one or more of the preceding claims characterized by the following steps:

a) providing a mat of thermoplastic fibers in which only a kind of thermoplastic fibres is comprised or a blend of at least two different kinds of thermoplastic fibres are comprised having different melting and or softening tenperatures;

b) calendering the mat of thermoplastic fibers while heating it at a temperature lower than the melting and/or softening temperature of the

thermoplastic fibers having the highest or the lowest melting and/or softening temperatures or after having heated the mat at the said temperature lower than the melting and/or softening temperature of the thermoplastic fibers having the highest or the lowest melting and/or softening temperatures;

b) heating the mat to a temperature higher than the melting or softening temperature of the thermoplastic fibers having the highest melting or softening temperature by hard or violent heating the panel on one or both faces through infrared radiation directed against the said one or both faces of the panel;

c) compressing the heated mat in a mold having two complementary shaped molding matrices;

d) cooling the panel.

77. A method according to claim 76, characterized in that the compression is exercised to such an extent to obtain a 30% to 90% reduction of the starting thickness of the mat.

78. A process for obtaining a first intermediate product for a panel according to one or more of the preceding claims, characterized in that starting form a mat of nonwoven thermoplastic fibers the said mat is submitted to heating at a temperature which is lower than the softening and/or melting temperature of the thermoplastic material of the fibers having the highest softening and/or melting temperature and calendering the said mat of fibres, heating being carried out during or immediately before calendering.

79. A process for producing a intermediate product for three dimensional shaped panels according to one or more of the preceding claims and with a method according to one or more of the preceding claims, characterized in that it comprises the steps of submitting to a violent surface heating a mat of thermoplastic fibres either directly or after preheating at a lower temperature than the softening and/or melting temperature of the thermoplastic material of the fibres having the highest or the lowest softening and/or melting temperature and calendering the said mat of fibres, heating being carried out during or immediately before calendering and molding the said violently heated mat in a mold countermold system having plane and parallel forming surfaces.

80. A method according to claim 79, characterized in that the violent heating process and/or the molding step are stopped before obtaining the desired phase distribution of the thermoplastic materials and the desired thickness of the final formed panel.

81 A method for producing a final thermoformed panel from an intermediate product according to claim 80, in which the final thermoformed panel is obtained from the said flat panel by a further violent heating step and three dimensional shaping step carried out at later stage on starting form the said intermediate flat or plane panel and in such a way as to complete the violent heating step for obtaining the desired distribution of the phase of the thermoplastic material along the thickness of the panel and the desired final

thickness of the panel.

82. An intermediate product characterized in that it is a flat or plane panel according to the method of claim 80.

83. A panel according to one or more of the preceding claims, characterized in that the hard or violent heating of the fibres is carried out by violently transferring a certain amount of thermal energy, i.e. heating with a certain temperature of the heaters and for a predetermined time and using heaters which heat transfer mean has a low thermal capacity.